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EGGSHELL DAMAGE FROM END OF PACKING LINE TO SUPERMARKET

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PREFACE AND ACKNOWLEDGMENT

This report is part of a continuing research program of the U.S. Department of Agriculture designed to find more efficient and less costly methods of packaging, handling, and transporting agricultural products from producer to consumer.

The egg grading on which this report is based was performed by State-licensed inspectors of the States in which the field work was performed.

Appreciation is extended to the State Departments of Agriculture of Alabama, Minnesota, and Texas for their highly dedicated and capable group of men who performed the egg grading and helped coordinate the study. Appreciation is also extended to the following who contributed their time and facilities: E. C. Hughes, Hughes Egg Farm, Warrior, Ala.; Stuart Fridell, Crystal Foods, Inc., Gaylord, Minn.; Frank and Jack Dubose, Continental Produce Co., Gonzales, Tex.; Marvin Posey, Cal-Maine Packing Plant, Lubbock, Tex.; and Floyd McCorkle, Cal-Maine Packing Plant (Post), Lubbock, Tex.

This study was conducted under the general direction of John C. Bouma, Chief, Market Operations Research Laboratory.

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EGGSHELL DAMAGE FROM END OF PACKING LINE TO SUPERMARKET

By Bruce E. Lederer[1]

ABSTRACT

The percentage rate of eggshell damage occurring between the end of the packing line and storage at the supermarket by age of laying hen, season of the year, and type of pack was determined (pack refers to the combination of master container type and stacking pattern of egg cartons within the container). The probability of checked shells at the plant becoming leakers during handling and distribution to supermarket when compared with sound shells at the plant was also determined. Research was done for 1 year in 3 States with 5 large packing plants and 16 supermarkets of various sizes cooperating.

The stacking pattern of the egg cartons within two types of master containers (corrugated paperboard cases and wire baskets) was either parallel-stacked or cross-stacked. Data were based on the inspection results of 24 truck shipments of shell eggs. Each shipment consisted of 20 test master containers. Damage rates were subjected to analyses of variance and Duncan's multiple range test to separate means. Statistical significance was at the 5-percent level of probability.

The mean rate of eggshell damage occurring between the end of the packing line and storage at the supermarket by age of laying hen ranged from 0.29 percent checks from birds under 40 weeks old to 2.02 percent checks from birds over 60 weeks old. There was no significant difference in the rate of leakers between age groups.

The mean rate of eggshell damage by season of the year ranged from 0.79 percent checks occurring to eggs produced and shipped in the winter to 2.20 percent in the summer. The rate of leakers appearing during the winter was significantly lower than in all other seasons.

The mean rate of eggshell damage by two types of master containers and two stacking patterns within each (pack) ranged from 1.28 percent checks to eggs that were cross-stacked in cases to 1.68 percent checks to eggs that were parallel-stacked in cases. There was no significant difference in the rate of leakers regardless of pack. During the summer season, a wider range of damage occurred with 1.57 percent checks to eggs whose cartons were cross-stacked in cases to 2.52 percent to eggs whose cartons were parallel-stacked in cases.

From the 2 percent of eggs that left the packing plant as checks, came 22.5 percent of the total leakers at the supermarkets. Therefore, checks leaving the packing plant had over 10 times the chance of becoming leakers by the time they reach the supermarket than the sound shell eggs.

KEYWORDS: Shell eggs, packaging, handling, checks, leakers.

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[1] Marketing specialist, Market Operations Research Laboratory, Beltsville Agricultural Research Center, Beltsville, Md. 20705.

INTRODUCTION

Some major factors influencing eggshell quality during distribution are the age of the laying hen, climatic conditions, handling methods, and packaging materials.

Recent studies have pinpointed the rates of damage and where the damage occurred along the distribution channel. The writer in his 1976 study[2] analyzed eggshell damage by four types of master containers in which the eggs were packed and by two major delivery systems. This publication is a continuation of the 1976 study.

PURPOSE OF STUDY

The purpose of this study was to determine the rate of eggshell damage along the distribution channel by age of laying hen, season of the year, and type of pack (pack refers to the combination of master container type and stacking pattern of egg cartons within the container).

Another purpose was to determine whether checked eggs sampled at the packing plant have a greater tendency to become leakers by the time they get to the supermarket than do sound shell eggs that left the plant.

A check is an individual egg that has a broken shell or crack in the shell with its shell membranes intact. Checks may range from a very fine hairlike check to plainly visible dented checks. A leaker is an individual egg that has a crack or break in the shell and the shell membrane to the extent that the egg contents are exuding or free to exude through the shell. Leakers are considered a loss in the USDA regulations.

MATERIALS AND METHODS

Most information was obtained from on-site inspection by State-licensed inspectors. Additional information was obtained from owners, managers, and employees of shell egg packing plants and supermarkets; Federal and State government officials; university personnel; and others involved with the handling of shell eggs.

Research was conducted in Alabama, Minnesota, and Texas from January 1976 to January 1977. Temperatures in these States during this period ranged from

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2/ Lederer, Bruce E. Eggshell damage and master container costs of two shell egg marketing systems. U.S. Dept. Agr., Agr. Res. Serv. ARS-NE-69, 1976.

a low of -30° F to a high of 102°. Cooperation in these States was obtained from 5 large packing plants and 16 retail supermarkets of various sizes.

The two types of master containers (fig. 1) were:

1. Corrugated paperboard case (30-dozen capacity) with 200-pound bursting strength; built in short Z liner for collapsible case and standard Z liner for noncollapsible case; in good to fair condition.

2. Wire basket (15-dozen capacity) in good to fair condition.

The stacking pattern of the egg cartons within the master containers was either parallel-stacked or cross-stacked. Although the shell egg industry uses parallel and cross stacking in paperboard cases and only parallel stacking in baskets, for purposes of this study, both stacking patterns were used in paperboard cases and in wire baskets.

In each test shipment the eggs were grade A or AA large and came from 36- to 70-week-old hens. The eggs were kept at temperatures ranging from 55° to 75° F with an 80 percent relative humidity. When they were ready to be packed and graded at the plant the eggs were 1 to 2 days old.

Throughout the study, several types of egg cartons were used but only one type was used for each individual truck shipment from plant to supermarket. All eggs for each shipment came from the same flock of birds.

PACKING AND GRADING PROCEDURES

There were 20 sample (fig. 2) master containers for each truck shipment. At the packing plant, the master containers for each shipment were packed as follows:

1. Within five paperboard cases, alternate tiers of egg cartons were stacked parallel to each other (fig. 2A). The bottom tier of cartons was placed either across or along the seam formed by the meeting of the bottom inner case flaps.

2. Within another five paperboard cases, alternate tiers of cartons were cross-stacked (fig. 2B). Again, the bottom tier of cartons was placed either across or along the seam.

3. Within five wire baskets, alternate tiers of cartons were stacked parallel to each other (fig. 2C).

4. Within another five wire baskets, alternate tiers of cartons were cross-stacked (fig. 2D).

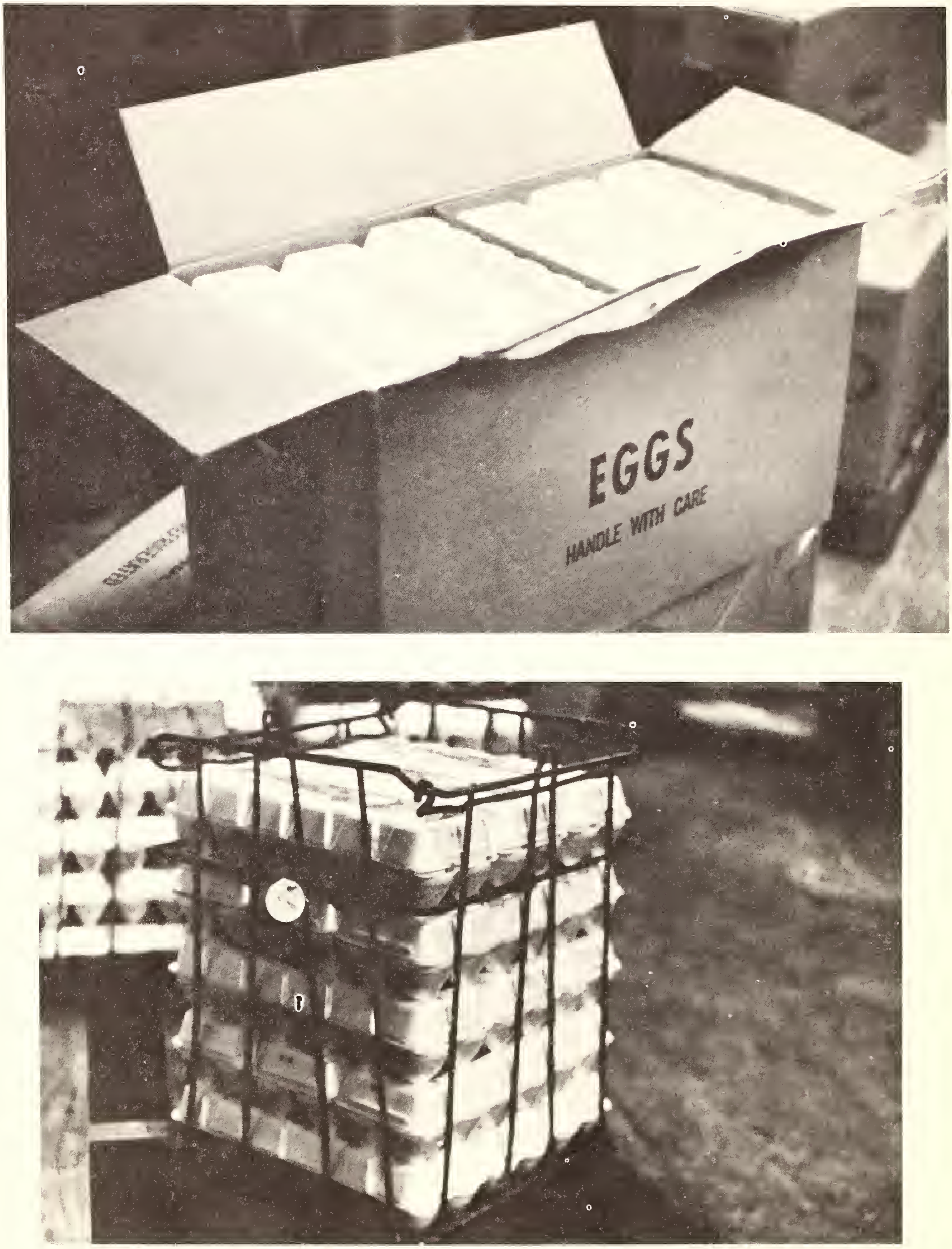

Figure 1.--Two types of master containers: Above, corrugated paperboard case (30-dozen capacity) and below, wire basket (15-dozen capacity.)

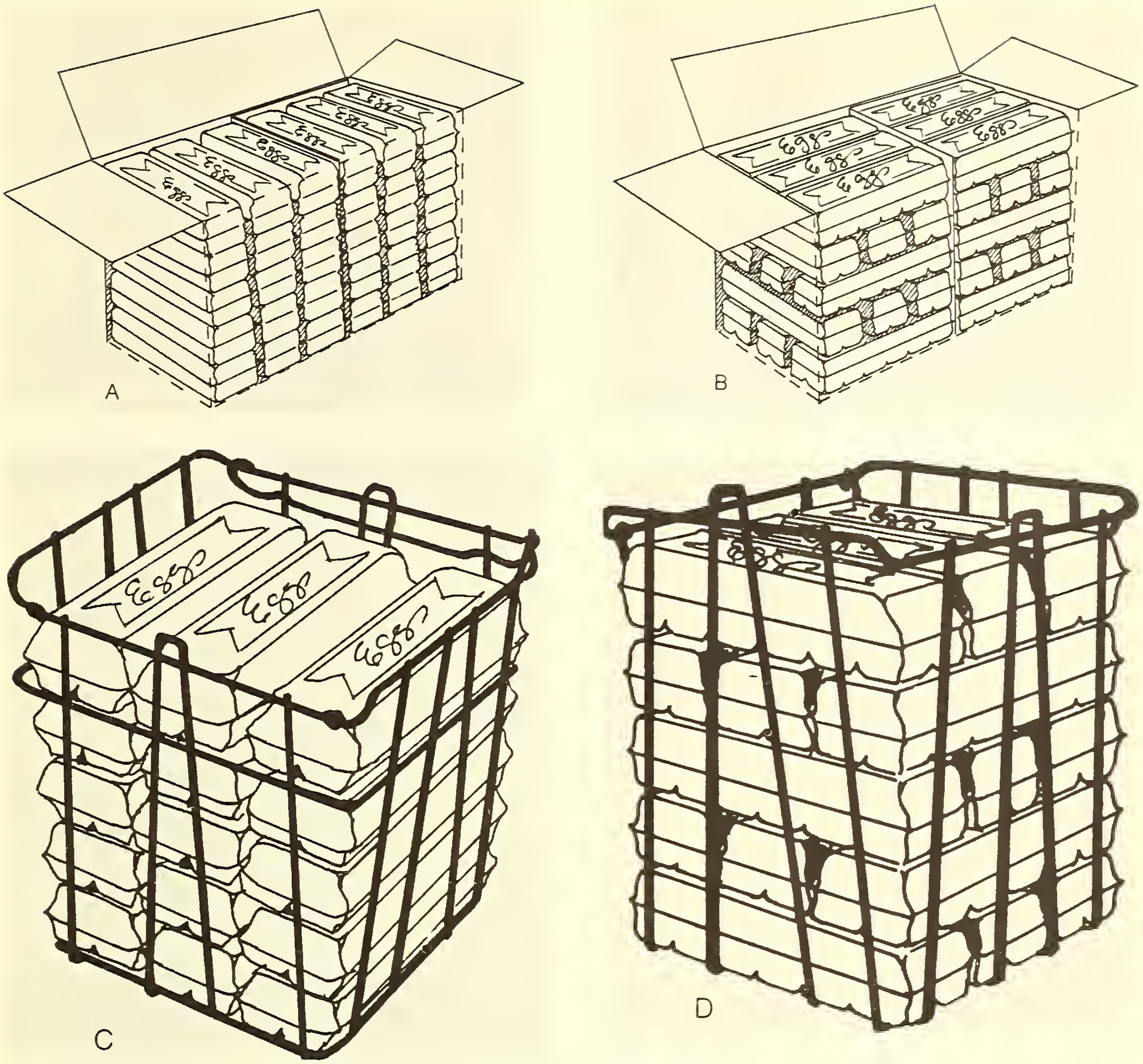

Figure 2.--Cross sections of the two stacking patterns within each master container: A, Parallel stacking in paperboard case; B, cross-stacking in paperboard case; C, parallel stacking in wire basket; D, cross-stacking in wire basket.

All sample containers were numbered consecutively and identified by shipment number and type of stacking pattern within each container. At each checkpoint graders cross-referenced the actual sample number when they recorded grading results.

At each checkpoint, graders inspected the eggs for checks and leakers only[3] in the marked samples according to the standard U.S. Department of Agriculture random sampling procedure.[4]

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[3] For definition of checks and leakers, see Purpose of Study.

[4] See Appendix--Sampling Procedures.

At the packing plant, checks were identified with a pen mark on the end of the egg and recorded on the worksheet. Leakers were recorded, after which they were removed and replaced with sound shell eggs.

At the retail stores, eggs with a pen mark were inspected to determine if they had developed into leakers, and all others in the sample were inspected for damage that might have occurred between the packing plant and supermarket. Checks with a pen mark were not recorded on the worksheet because they had been already recorded at the packing plant. All the newly damaged eggs were determined and recorded, after which they were removed from the cartons and discarded. The remainder of the eggs were consolidated into complete dozens and sold at the store.

After information on egg shell damage was collected, data were subjected to analysis of variance and Duncan's multiple range test to separate means. Statistical significance was at the 5-percent level of probability.

Of the 28 truck shipments of sampled eggs, 4 were eliminated because of improper or unequal handling of some egg containers. Therefore, the data on 24 egg shipments were included. The total number of eggs inspected (candled) within the 24 shipments were:

Location	Number of eggs
Packing plant	48,000
Supermarket	46,600[5]
Total	94,600

Most shipments were delivered on straight body trucks for short hauls or tractor trailers for long hauls (fig. 3). The one-way distance between packing plant and supermarket ranged from 105 to 330 miles. The transport vehicles were all fully loaded. The test containers were randomly hand-stacked (unpalletized) at the rear of the vehicles where the ride was the roughest. Driver competence varied as did the suspension of the vehicles and road conditions.

Because there were 5 packing plants and 16 supermarkets involved, handling methods varied considerably. The description here is considered typical for the majority of the facilities. It should be noted that, although handling methods differed from plant to plant and from supermarket to supermarket, each master container of eggs within each individual shipment was handled the same as every other container in the shipment. This kept chances of damage to any one of them equal.

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[5] Of the shell eggs shipped from the packing plant, 1,400 were not inspected at the retail store because the 14 master containers they were packed in received unequal treatment in transit.

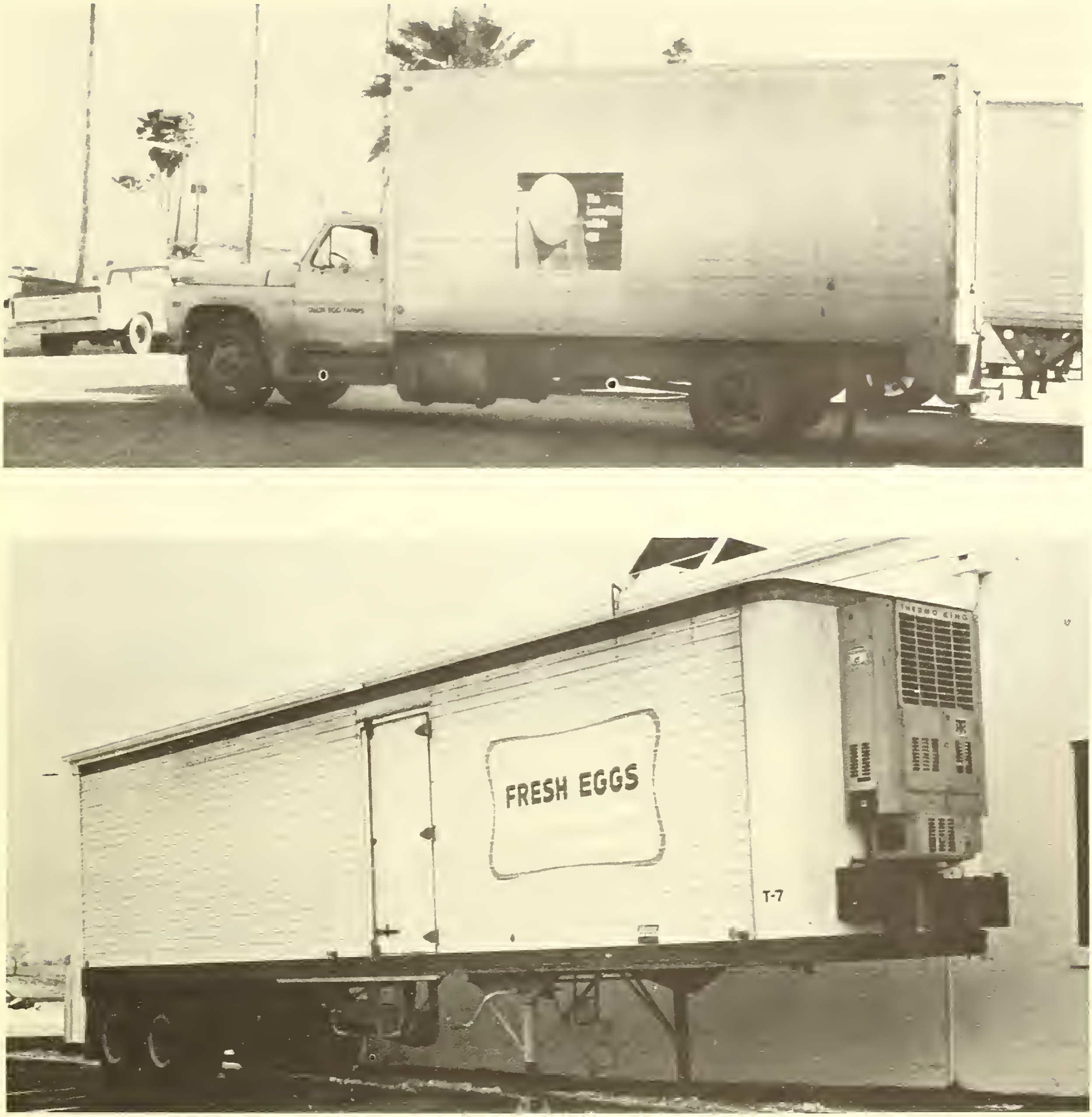

Figure 3.--Two principal modes of shipment: Above, straight body truck used for short hauls and below, trailer used for long hauls.

At the packing plant cartons of eggs were packed in cardboard cases or in wire baskets on the packing line and the container placed nearby on the floor or on pallets (fig. 4). If the containers had been packed properly (cross-stacked

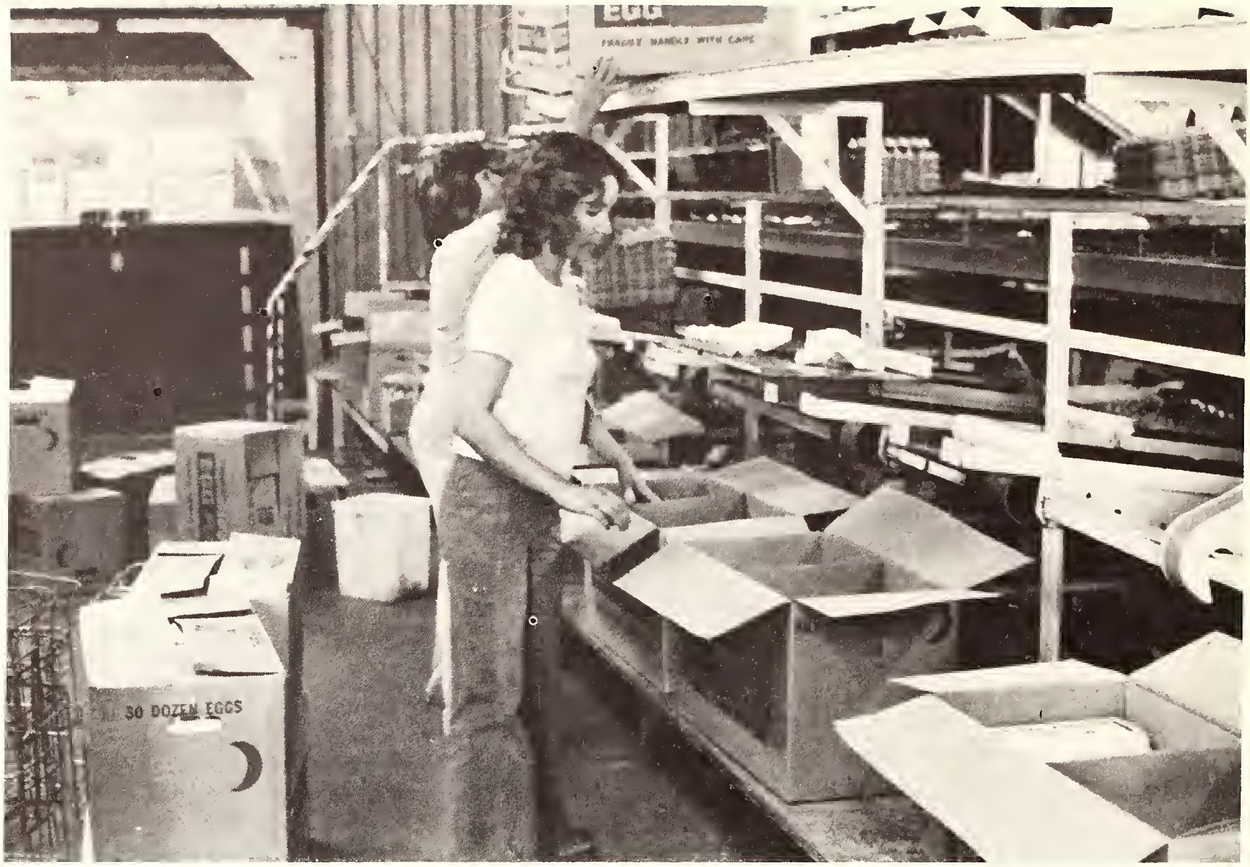

Figure 4.--Packing master containers on the packing line.

or parallel-stacked), they were hand-carried 5 to 30 feet to the grading area, identified by pen or tag on the outside of the container, and then graded (fig. 5). If the containers had not been packed properly, they were moved to the grading area, repacked in the appropriate manner, identified, and then graded. After grading, the master containers were placed on pallets and moved by electric or hydraulic pallet transporters to the cooler. Each pallet had 20 master containers on it--10 cardboard cases and 10 wire baskets. Of the 10 cases, 5 were cross-packed and 5 parallel-packed. Of the 10 baskets, 5 were cross-packed and 5 parallel-packed. These 20 master containers made up one shipment. After sitting from 8 hours to 4 days in the cooler, a pallet of eggs was transported to the loading dock and handstacked randomly at the rear of the delivery vehicle. This process was repeated basically the same for all shipments.

At the retail store, the eggs were unloaded either at street level or at dock height. Most shipments were unloaded by 2- or 4-wheeled handtrucks, others by conveyor belt. The containers of eggs were moved to the grading area of the particular supermarket and inspected.

Figure 5.--Egg grading.

INSPECTION RESULTS

This section reflects the rate of damage found at the packing plant and supermarket checkpoints by each variable studied. Although tables 1 to 4 show the mean rate of eggshell damage occurring at the packing plants and supermarkets, only data from the supermarket are discussed. The damage at the packing plant is shown only to reflect the starting base upon which additional damage within the distribution network was added.

Table 1 shows the mean rate of eggshell damage by age of laying hens. The percentage of checks at the supermarket was significantly lower from birds under 40 weeks old (0.29 percent) than from birds from 40 to 60 weeks old (1.7 percent) and over 60 weeks old (2.02 percent). There was no significant difference in the rate of leakers between age groups.

Table 2 shows the mean rate of eggshell damage by season of the year. A significantly lower percentage rate of checks and leakers occurred to eggs that were produced and shipped in the winter (0.79 percent and 0.05 percent, respec-

Table 1.--Mean rate of eggshell damage by age of laying hens

Hen age (weeks)	Inspection stations					
	Packing plant		Supermarket		Total	
	Checks	Leakers	Checks	Leakers	Checks	Leakers
	Percent					
Under 40	0.85	0.10	0.29	0.00	1.14	0.10
40 to 60	2.81	.21	1.70	.15	4.51	.36
Over 60	2.78	.50	2.02	.18	4.80	.68

Table 2.--Mean rate of eggshell damage by season of year

Season	Inspection stations					
	Packing plant		Supermarket		Total	
	Checks	Leakers	Checks	Leakers	Checks	Leakers
	Percent					
Summer	3.25	0.33	2.20	0.15	5.45	0.48
Spring and fall	2.71	.19	1.44	.26	4.15	.45
Winter	1.59	.12	.79	.05	2.38	.17

tively) than those in all other seasons of the year. A significantly lower rate of checks (1.44 percent) occurred to eggs produced and shipped in spring and fall than those in the summer (2.20 percent). There was no significant difference in the mean percentage rates of leakers between spring-fall and summer.

Table 3 shows the mean rate of eggshell damage by two types of master containers and two stacking patterns within each type of pack. The percentage rate of checks that were cross-stacked in cases (1.28 percent) was significantly lower than those that were parallel-stacked in cases (1.68 percent). There was no significant difference in the mean rate of leakers regardless of the type of pack.

Table 4 reflects the mean rate of eggshell damage occurring only during the summer because more damage occurs in the warmer months of the year. It is interesting to note that the damage rates are greater in the summer months, yet almost the same relationship of damage rates between the four packs is maintained with one exception. There is a significant difference not only between checks that are cross-stacked in cardboard cases (1.57 percent) and checks that are parallel-stacked in cases (2.52 percent), but also between checks that are cross-stacked in cases and those in both basket packs. Shell eggs cross-stacked in cases showed a clearly lower rate of damage than eggs in the other three packs.

Table 3.--Mean rate of eggshell damage by 2 types of master containers and 2 stacking patterns within each pack

Pack	Inspection station				Total	
	Packing plant		Supermarket			
	Checks	Leakers	Checks	Leakers	Checks	Leakers
	Percent					
Wire basket:						
Parallel-stacked	2.37	0.19	1.39	0.07	3.76	0.26
Cross-stacked	2.75	.29	1.58	.14	4.33	.43
Paperboard case:						
Parallel-stacked	2.37	.23	1.68	.15	4.05	.38
Cross-stacked	2.38	.17	1.28	.13	3.66	.30

Table 4.--Mean rate of eggshell damage occurring between packing plant and supermarket during the summer months by type of pack

Pack	Inspection station				Total	
	Packing plant		Supermarket			
	Checks	Leakers	Checks	Leakers	Checks	Leakers
	Percent					
Basket:						
Parallel-stacked	3.23	0.27	2.28	0.13	5.51	0.40
Cross-stacked	3.21	.48	2.41	.29	5.62	.77
Paperboard case:						
Parallel-stacked	3.26	.32	2.52	.10	5.78	.42
Cross-stacked	3.32	.24	1.57	.08	4.89	.32

Table 5 shows that from the 2 percent of checks at the packing plant came 22.5 percent of the leakers at the supermarket. Therefore, checks leaving the plant had over 10 times the chance of becoming leakers than eggs with sound shells.

Table 5.--A comparison of sound shells that became leakers between packing plant and supermarket with checks that became leakers

Shell condition	Packing plant		Supermarket leakers	
	Number	Percent	Number	Percent
Sound	47,040	98	69	77.5
Check	960	2	20	22.5
Total or average	48,000	100	89	100.0

CONCLUSION AND RECOMMENDATIONS

Packing materials and methods for eggs become more critical as the age of laying hen increased and climatic temperature rose. Also, eggshells had higher damage rates at both the packing plant and the supermarket when these conditions were present. A significant difference in damage rates of eggs existed depending upon the method of stacking the egg cartons in their respective master containers.

In warm or hot weather, when cartons were cross-stacked in paperboard cases cases, checks were 38 percent lower than those parallel-stacked in paperboard cases, 35 percent lower than those cross-stacked in wire baskets, and 31 percent lower than those parallel-stacked in wire baskets.

As the propensity for damage increases, the protection afforded by cross-stacking in paperboard cases also increases to a significant extent.

This study also reflects the high percentage rate of leakers that occurred to eggs that were initially checked at the packing plant. Although the total percentage rate of leakers at the supermarket check points was low, one should be aware of the high proportion of that rate which was caused by a very low proportion of eggs.

It should be noted that although the mean percentage rates of checks and leakers appear small, when the difference in damage rates are projected over the entire shell egg industry, the small differences add up to an appreciable amount. Therefore, the use of the most efficient stacking pattern is recommended to keep damage to a minimum. In addition, by keeping checks that leave the packing plant to a minimum, one can significantly reduce the rate of leakers that appear at the supermarket.

APPENDIX--SAMPLING PROCEDURES

At each checkpoint, graders inspected (candled) 100 shell eggs from each sample corrugated cardboard case or wire basket. One-half of the total eggs candled from the corrugated cases were taken from the numbered end of the cases and the other one-half from the opposite end of the cases. For example, on odd-numbered cases, such as 1, 3, and 5, the marked end of the case was examined, and on the even-numbered cases, such as 2, 4, and 6, the unmarked end was examined.

Eggs within each case and basket were selected in the following rotation:

Container 1 - Cartons in layers 1, 2, and all except eight eggs in the third layer.

Container 2 - Cartons in layers 3, 4, and all except eight eggs in the fifth layer.

Container 3 - Cartons in layers 2, 3, and all except eight eggs in the fourth layer.

Container 4 - Cartons in layers 1, 2, and all except eight eggs in the fifth layer.

Container 5 - Cartons in layers 1, 4, and all except eight eggs in the fifth layer.

The above order of selection was repeated for all remaining sample cardboard cases and wire baskets.

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